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This invention relates to proteins or peptides which elicit T cell mediated immunity, and to cancer vaccines and compositions for anti-cancer treatment comprising such proteins or peptide fragments. This invention also relates to pharmaceutical compositions comprising the proteins or peptides and methods for generating T lymphocytes capable of recognising and destroying tumour cells in a mammal.

Cancer develops through a multistep process involving several mutational events. These mutations result in altered expression/function of genes belonging to two categories: oncogenes and tumour suppressor genes. Oncogenes arise in nature from proto-oncogenes through point mutations or translocations, thereby resulting in a transformed state of the cell harbouring the mutation. All oncogenes code for and function through a protein. Proto-oncogenes are normal genes of the cell which have the potential of becoming oncogenes. In the majority of cases, proto-oncogenes have been shown to be components of signal transduction pathways. Oncogenes act in a dominant fashion. Tumour-suppressor genes on the other hand, act in a recessive fashion, i.e. through loss of function, and contribute to oncogenesis when both alleles encoding the functional protein have been altered to produce non-functional gene products.

The concerted action of a combination of altered oncogenes and tumour-suppressor genes results in cellular transformation and development of a malignant phenotype.

Such cells are however prone to senescence and have a limited life-span. In the majority of cancers, immortalisation of the tumour cells requires the turning on of an enzyme complex called telomerase. In somatic cells the catalytic subunit of this enzyme is normally not expressed. Additional events, such as the action of proteins encoded by a tumour virus or demethylation of silenced promoter sites can result in expression of a functional telomerase complex in tumour cells.

In the field of human cancer immunology, the last two decades have seen intensive efforts to characterise genuine cancer specific antigens. In particular, effort has been devoted to the analysis of antibodies to human tumour antigens. The prior art suggests that such antibodies can be used for diagnostic and therapeutic purposes, for instance in connection with an anti-cancer agent. However, antibodies can only bind to tumour antigens that are exposed on the surface of tumour cells. For this reason, the efforts to produce a cancer treatment based on the immune system of the body has been less successful than expected.

A fundamental feature of the immune system is that it can distinguish self from nonself and does not normally react against self molecules. It has been shown that rejection of tissues or organs grafted from other individuals is an immune response to the foreign antigens on the surface of the grafted cells. The immune response in general consists of a humeral response, mediated by antibodies, and a cellular response. Antibodies are produced and secreted by B lymphocytes, and typically recognise free antigen in native conformation. They can therefore potentially recognise almost any site exposed on the antigen surface. In contrast to antibodies, T cells, which mediate the cellular arm of the immune response, recognise antigens only in the context of MHC molecules, and only after appropriate antigen processing. This antigen processing usually consists of proteolytic

fragmentation of the protein, resulting in peptides that fit into the groove of the MHC molecules. This enables T cells to also recognise peptides derived from intracellular antigens.

T cells can recognise aberrant peptides derived from anywhere in the tumour cell, in the context of MHC molecules on the surface of the tumour cell. The T cells can subsequently be activated to eliminate the tumour cell harbouring the aberrant peptide. In experimental models involving murine tumours it has been shown that point mutations in intracellular "self" proteins may give rise to tumour rejection antigens, consisting of peptides differing in a single amino acid from the normal peptide. The T cells recognising these peptides in the context of the major histocompatibility (MHC) molecules on the surface of the tumour cells are capable of killing the tumour cells and thus rejecting the tumour from the host (Boon et al.,1989, Cell 58, 293-303).

MHC molecules in humans are normally referred to as HLA (human leucocyte associated antigen) molecules. There are two principal classes of HLA molecules, class I and class II. HLA class I molecules are encoded by HLA A, B and C subloci and primarily activate CD8+ cytotoxic T cells. HLA class II molecules, on the other hand, primarily activate CD4+ T cells, and are encoded by the DR, DP and DQ subloci. Every individual normally has six different HLA class I molecules, usually two alleles from each of the three subgroups A, B and C, although in some cases the number of different HLA class I molecules is reduced due to the occurrence of the same HLA allele twice.

The HLA gene products are highly polymorphic. Different individuals express distinct HLA molecules that differ from those found in other individuals. This explains the difficulty of finding HLA matched organ donors in transplantations. The significance of the genetic variation

of the HLA molecules in immunobiology is reflected by their role as immune-response genes. Through their peptide binding capacity, the presence or absence of certain HLA molecules governs the capacity of an individual to respond to specific peptide epitopes. As a consequence, HLA molecules determine resistance or susceptibility to disease.

T cells may inhibit the development and growth of cancer by a variety of mechanisms. Cytotoxic T cells, both HLA class I restricted CD8+ and HLA class II restricted CD4+ may directly kill tumour cells presenting the appropriate tumour antigens. Normally, CD4+ helper T cells are needed for cytotoxic CD8+ T cell responses, but if the peptide antigen is presented by an appropriate APC, cytotoxic CD8+ T cells can be activated directly, which results in a quicker, stronger and more efficient response.

While the peptides that are presented by HLA class II molecules are of varying length (12-25 amino acids), the peptides presented by HLA class I molecules must normally be exactly nine amino acid residues long in order to fit into the class I HLA binding groove. A longer peptide will result in non-binding if it cannot be processed internally by an APC or target cell, such as a cancer cell, before presenting in the class I HLA groove. Only a limited number of deviations from this requirement of nine amino acids have been reported, and in those cases the length of the presented peptide has been either eight or ten amino acid residues long.

Reviews of how MHC binds peptides can be found in Hans-Georg Rammensee, Thomas Friede and Stefan Stevanovic, (1995, Immunogenetics, 41, 178-228) and in Barinaga (1992, *Science* 257, 880-881). Male et al (1987, *Advanced Immunology*, J.B. Lippincott Company, Philadelphia) offers a more comprehensive explanation of the technical background to this invention.

In our International Application PCT/N092/00032 (published as WO92/14756), we described synthetic peptides and fragments of oncogene protein products which have a point of mutation or translocations as compared to their proto-oncogene or tumour suppressor gene protein. These peptides correspond to, completely cover or are fragments of the processed oncogene protein fragment or tumour suppressor gene fragment as presented by cancer cells or other antigen presenting cells, and are presented as a HLA-peptide complex by at least one allele in every individual. These peptides were also shown to induce specific T cell responses to the actual oncogene protein fragment produced by the cell by processing and presented in the HLA molecule. In particular, we described peptides derived from the p21-*ras* protein which had point mutations at particular amino acid positions, namely positions 12, 13 and 61. These peptides have been shown to be effective in regulating the growth of cancer cells *in vitro*. Furthermore, the peptides were shown to elicit CD4+ T cell immunity against cancer cells harbouring the mutated p21-*ras* oncogene protein through the administration of such peptides in vaccination or cancer therapy schemes. Later we have shown that these peptides also elicit CD8+ T cell immunity against cancer cells harbouring the mutated p21 *ras* oncogene protein through the administration mentioned above (see M.K. Gjertsen et al., Int. J cancer, 1997, vol. 72 p. 784).

However, the peptides described above will be useful only in certain numbers of cancers, namely those which involve oncogenes with point mutations or translocation in a proto-oncogene or tumour suppressor gene. There is therefore a strong need for an anticancer treatment or vaccine which will be effective against a more general range of cancers.

In general, tumours are very heterogeneous with respect to genetic alterations found in the tumour cells. This implies that both the potential therapeutic effect and prophylactic

strength of a cancer vaccine will increase with the number of targets that the vaccine is able to elicit T cell immunity against. A multiple target vaccine will also reduce the risk of new tumour formation by treatment escape variants from the primary tumour.

The enzyme telomerase has recently been the focus of attention for its supposed role in prevention of cellular ageing. Telomerase is a RNA-dependent DNA polymerase, which synthesises telomeric DNA repeats using an RNA template that exists as a subunit of the telomerase holoenzyme. The DNA repeats synthesised by the enzyme are incorporated into telomeres, which are specialised DNA-protein structures found at the ends of the linear DNA molecules which make up every chromosome. Telomerase was first identified in the ciliate *Tetrahymena* (Greider and Blackburn, 1985, *Cell* 43, 405-413). A human telomerase catalytic subunit sequence was recently identified by Meyerson et al (1990, *Cell* 1197 , 785-795), and Nakamura et al (1997, *Science* 277, 955-959), who respectively named the gene hEST2 and hTRT. In addition, three other proteins which are associated with telomerase activity have also been identified: p80 and p95 of *Tetrahymena* (Collins et al, 1995, *Cell* 81, 677-686) and TP1/TLP1, which is the mammalian homologue of *Tetrahymena* p80 (Harrington et al, 1997, *Science*, 275, 973-977; Nakayama et al., 1997, *Cell* 88, 875-884).

Telomerase is not expressed in most normal cells in the body. Most somatic lineages in humans show no detectable telomerase activity, but telomerase activity is detected the germline and in some stem cell compartments, which are sites of active cell division (Harley et al., 1994, *Cold Spring Harbor Symp. Quant. Biol.* 59, 307-315; Kim et al., 1994, *Science* 266, 2011-2015; Broccoli et al, 1995, *PNAS USA* 92, 9082-9086; Counter et al., 1995, *Blood* 85, 2315-2320; Hiyama et al., 1995, *J. Immunol.* 155, 3711-3715). Telomeres of most types of

human somatic cells shorten with increasing age of the organism, consistent with lack of telomerase activity in these cells. Cultured human cells also show telomere shortening. Telomere shortening continues in cultured human cells which have been transformed, until the telomeres have become critically short. At this point, termed the crisis point, significant levels of cell death and karyotypic instability are observed.

Immortal cells, which have acquired the ability to grow indefinitely in culture, emerge at rare frequency from crisis populations. These immortal cells have high levels of telomerase activity and stable telomeres. Telomerase activity is also readily detected in the great majority of human tumour samples analysed to date (Kim et al, 1994, *Science* 266, 2011-2015), including ovarian carcinoma (Counter et al., 1994, *PNAS USA* 91, 2900-2904). A comprehensive review is provided by Shay and Bachetti (1997, *Eur. J. Cancer* 33, 787-791). Thus, activation of telomerase may overcome the barriers to continuous cell division imposed by telomere length. Cells that overcome the normal senescence mechanisms may do so by stabilising telomere length, probably due to the activity of telomerase.

Viruses implicated in human cancer development such as Epstein Barr virus (EBV, related to B cell malignancies and nasopharyngeal carcinomas) and Human Papilloma virus (HPV 16 and 18, related to cervical carcinomas) have long been known to have the capacity to immortalize human cells. It has now been demonstrated that induction of telomerase activity is the key element in this process (Klingelhutz et al, 1996, *Nature*, 380, 79-82).

Telomerase is therefore a potential target for cancer therapy. Thus, telomerase inhibitors have been proposed as a new class of anti-cancer drugs (reviewed in Sharma et al,

1997, *Ann Oncol* 8(11), 1063-1074; Axelrod, 1996, *Nature Med* 2(2), 158-159; Huminiecki, 1996, *Acta Biochim Pol*, 43(3), 531-538). It has been suggested that the identification of a human telomerase catalytic subunit may provide a biochemical reagent for identifying such drugs (Meyerson et al, 1990, *Cell* 1197, 785-795). Telomerase has also been suggested to be a marker for diagnosis or prognosis of cancer (Soria and Rixe, 1997, *Bull Cancer* 84(10), 963-970; Dahse et al, 1997, *Clin Chem* 43(5), 708-714).

As far as we are aware, however, no one has previously suggested that telomerase may function as a useful target for T cell mediated therapy, or that telomerase peptides or proteins may be used for the treatment or prophylaxis of cancer.

In accordance with one aspect of the invention, we provide a telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer.

In accordance with a second aspect of the invention, there is provided a nucleic acid for use in a method of treatment or prophylaxis of cancer, the nucleic acid being capable of encoding a telomerase protein or peptide as provided in the first aspect of this invention.

We provide, in accordance with a third aspect of this invention a pharmaceutical composition comprising at least one telomerase protein or peptide or nucleic acid as provided in the first or second aspect of this invention and a pharmaceutically acceptable carrier or diluent.

According to a fourth aspect of this invention, we provide a method for the preparation of a pharmaceutical composition as provided in the third aspect of the invention, the method comprising mixing at least one telomerase protein or peptide

or nucleic acid as provided in the first or second aspect of the invention with a pharmaceutically acceptable carrier or diluent.

There is further provided, according to a fifth aspect of this invention a pharmaceutical composition comprising a combination of at least one telomerase protein or peptide as provided in the first aspect of this invention and at least one peptide capable of inducing a T cell response against an oncogene or mutant tumour suppressor protein or peptide, together with a pharmaceutically acceptable carrier or diluent.

We further provide, in accordance with a sixth aspect of this invention, a method for the preparation of a pharmaceutical composition as provided in the fifth aspect of this invention, the method comprising mixing at least one telomerase protein or peptide provided in the first aspect of this invention, with at least one peptide capable of inducing a T cell response against an oncogene or tumour suppressor protein or peptide, and a pharmaceutically acceptable carrier or diluent.

In accordance with a seventh aspect of this invention, we provide the use, in the preparation of a medicament for the treatment or prophylaxis of cancer, of a telomerase protein or peptide, or a nucleic acid capable of encoding a telomerase protein or peptide.

According to a eighth aspect of this invention, there is provided a method of generating T lymphocytes capable of recognising and destroying tumour cells in a mammal, comprising taking a sample of T lymphocytes from a mammal, and culturing the T lymphocyte sample in the presence of telomerase protein or peptide in an amount sufficient to generate telomerase protein or peptide specific T lymphocytes.

The invention is more particularly described, by way of example only, with reference to the accompanying drawing, in which:

FIGURE 1 shows the sequences of the conserved amino acid motifs in the human telomerase catalytic subunit, as identified by Meyerson et al (1997, Cell 90, 785-795) and Nakamura et al (1997 *Science* 277, 955-959). Motifs T, 1, 2, 3 (A of Nakamura), 4 (B'of Nakamura) 5 (C of Nakamura), 6 (D of Nakamura) and E are shown. Peptides may be synthesised with sequences corresponding to or encompassing any of the bracketed regions. The designations A2, A1, A3 and B7 indicate peptides which are likely to be presented by HLA-A2, HLA-A1, HLA-A3 and HLA-B7 respectively.

We provide a telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer. In a preferred embodiment, the method comprises generating a T cell response against telomerase. The method may comprise administering to a mammal, preferably a human, suffering or likely to suffer from cancer a therapeutically effective amount of the telomerase protein or peptide so that a T cell response against the telomerase is induced in the mammal.

Telomerase specific T cells may be used to target cells which express telomerase. Thus, since most cells in the body of an organism do not express telomerase, they will be unaffected. However, tumour cells that express telomerase will be targeted and destroyed. As telomerase activity has been detected in the majority of cancers identified so far, we expect our materials and methods to have widespread utility.

Cancers which are suitable for treatment include, but are not limited to, breast cancer, prostate cancer, pancreatic cancer, colo-rectal cancer, lung cancer, malignant melanoma,

leukaemias, lymphomas, ovarian cancer, cervical cancer and biliary tract carcinomas.

As used here, the term telomerase denotes a ribonucleoprotein enzyme which has telomere elongating activity. Telomerase protein as used here denotes any protein component of telomerase, including any subunit having catalytic activity.

Preferably the telomerase protein is a mammalian telomerase protein, and most preferably a human telomerase protein. The human telomerase protein is preferably the telomerase catalytic subunit identified as hTRT by Nakamura et al (1997, *Science* 277, 955-959) and hEST2 by Meyerson et al (1990, *Cell* 1197 , 785-795), the cDNA sequences of which are deposited as GenBank accession numbers AF015950 and AF018167 respectively.

The term telomerase peptide as used here means a peptide which has an amino acid sequence corresponding to a sequence present in the amino acid sequence of a telomerase protein. The telomerase peptides preferably contain between 8 and 25 amino acids. More preferably, the telomerase peptides contain between 9 and 25 amino acids. For instance, the telomerase peptides contain 9, 12, 13, 16 or 21 amino acids.

The telomerase protein or peptide is chosen so that it is capable of generating a T cell response directed against the telomerase protein (or against the telomerase protein from which the telomerase peptide is derived). In preferred embodiments, the T cell response induced is a cytotoxic T cell response. The cytotoxic T cell response may be a CD4+ T cell response, or it may be a CD8+ T cell response. In any case, the peptide must be capable of being presented as a complex with a MHC class I or class II protein on the surface of tumour cells or antigen presenting cells, with antigen processing taking place beforehand if necessary.

The telomerase peptide may include one or more amino acid residues from an amino acid motif essential for the biological function of the telomerase protein; in other words, it may overlap at least partially with such an amino acid motif. Examples of such amino acid motifs are motifs 1 to 6 of the human telomerase catalytic subunit sequence hEST2 as identified by Meyerson et al (1990, *Cell* 1197, 785-795), in other words, from the motifs

LLRSFFYVTE
SRLRFIPK,
LRPIVNMDYVVG,
PELYFVKVDVTGAYDTI,
KSYVQCQGIPQGSILSTLLCSLCY,
LLLRLVDDFLLVT and
GCVVNLRKTVV

or from any of motifs T, 1, 2, A, B', C, D or E as identified by Nakamura et al (1997, *Science* 277, 955-959) in the hTRT sequence, namely, the motifs

WLMSVYVVELLRSFFYVTETTFQKNRLFFYRKSVWSKLQSIGIRQHLK,
EVRQHREARPALLTSRLRFIPKPDG,
LRPIVNMDYVVGARTFRREKRAERLTSRV,
PPPELYFVKVDVTGAYDTIPQDRLTEVIASIIKP,
KSYVQCQGIPQGSILSTLLCSLCYGDMENKLFAGI,
LLRLVDDFLLVTPHLTH,
AKTFLRTLVRGVPEYGCVVNLRKTVV and HGLFPWCGLLL.

Suitable peptides which may be used in the methods and compositions described here are set out in TABLE 1 as well as in the attached sequence identity list.

Another set of suitable peptides derived from elsewhere in the telomerase sequence, which may be used in the methods and compositions described here, are set out in TABLE 2.

Also included are proteins and peptides having amino acid sequences corresponding to an amino acid sequence present in

the amino acid sequence of mammalian homologues of the *Tetrahymena* telomerase associated proteins p80 and p95. For example, the p80 homologues TP1 and TLP1 (Harrington et al, 1997, *Science*, 275, 973-977; Nakayama et al., 1997, *Cell* 88, 875-884).

Larger peptide fragments carrying a few amino acid substitutions at either the N-terminal end or the C-terminal end are also included, as it has been established that such peptides may give rise to T cell clones having the appropriate specificity.

The peptides described here are particularly suited for use in a vaccine capable of safely eliciting either CD4+ or CD8+ T cell immunity:

a) the peptides are synthetically produced and therefore do not include transforming cancer genes or other sites or materials which might produce deleterious effects,

(b) the peptides may be used alone to induce cellular immunity,

(c) the peptides may be targeted for a particular type of T cell response without the side effects of other unwanted responses.

The telomerase peptides or proteins described here can be administered in an amount in the range of 1 microgram (1µg) to 1 gram (1g) to an average human patient or individual to be vaccinated. It is preferred to use a smaller dose in the range of 1 microgram (1µg) to 1 milligram (1mg) for each administration.

In preferred embodiments, the telomerase protein or peptide is provided to the patient in the form of a pharmaceutical composition. The telomerase protein or peptide may be administered as a mixture of proteins or a mixture of proteins and peptides or a mixture of peptides. The

pharmaceutical composition may in addition include the usual additives, diluents, stabilisers or the like as known in the art.

The pharmaceutical composition may comprise one or more telomerase proteins or peptides. The protein or peptide mixture may be any one of the following:

(a) a mixture of peptides having different sequences, for example, corresponding to different portions of a telomerase protein sequence;

(b) a mixture of peptides having overlapping sequences, but suitable to fit different HLA alleles;

(c) a mixture of both mixtures (a) and (b);

(d) a mixture of several mixtures (a);

(e) a mixture of several mixtures (b);

(f) a mixture of several mixtures (a) and several mixtures (b);

In each case, a mixture of proteins or peptides corresponding to different telomerase proteins, for example, a telomerase catalytic subunit and a *Tetrahymena* p80 or p95 homologue, may also be used.

Alternatively, the telomerase peptides in the mixture may be covalently linked with each other to form larger polypeptides or even cyclic polypeptides. The pharmaceutical composition may be made by mixing the telomerase protein(s) or peptide(s) with a pharmaceutically acceptable carrier or diluent.

The pharmaceutical composition may also include at least one peptide capable of inducing a T cell response against an oncogene or mutant tumour suppressor protein or peptide. Alternatively, the telomerase proteins or peptides may be administered either simultaneously or in optional sequence with these peptides. Examples of oncogene proteins are the p21-*ras* proteins H-ras, K-ras and N-ras, abl, gip, gsp, ret

and trk. Preferably, the oncogene protein or peptide is a p21-*ras* protein or peptide, for example, the p21-*ras* peptides described in our International Application PCT/NO92/00032 (publication number WO92/14756). Tumour suppressor proteins include p53 and Rb (retinoblastoma). Such a pharmaceutical composition may be made by mixing the telomerase protein(s) or peptide(s) with the mutant tumour suppressor or oncogene proteins or peptides, together with a pharmaceutically acceptable carrier or diluent.

As used here, the term mutant refers to a wild type sequence which has one or more of the following: point mutation (transition or transversion), deletion, insertion, duplication translocation or inversion. The term pharmaceutical composition not only encompasses a composition usable in treatment of cancer patients, but also includes compositions useful in connection with prophylaxis, i.e., vaccine compositions.

The telomerase peptides or proteins are administered to a human individual in need of such treatment or prophylaxis. The administration may take place one or several times as suitable to establish and/or maintain the wanted T cell immunity. The peptides may be administered together, either simultaneously or separately, with compounds such as cytokines and/or growth factors, i.e., interleukin-2 (IL-2), interleukin-12 (IL-12), granulocyte macrophage colony stimulating factor (GM-CSF) or the like in order to strengthen the immune response as known in the art. The telomerase proteins or peptides can be used in a vaccine or a therapeutical composition either alone or in combination with other materials. For example, the peptide or peptides may be supplied in the form of a lipopeptide conjugate which is known to induce a high-affinity cytotoxic T cell response (Deres, 1989, *Nature* 342).

The peptides and proteins mentioned above as possible constituents of the pharmaceutical composition may be provided in the form of nucleic acid encoding the particular peptide or protein. Thus, the pharmaceutical composition may consist of peptide and/or protein alone, or in combination with nucleic acid, or it may consist of mixtures of nucleic acids.

The telomerase peptides or proteins may be administered to an individual in the form of DNA vaccines. The DNA encoding the telomerase peptide or protein may be in the form of cloned plasmid DNA or synthetic oligonucleotide. The DNA may be delivered together with cytokines, such as IL-2, and/or other co-stimulatory molecules. The cytokines and/or co-stimulatory molecules may themselves be delivered in the form of plasmid or oligonucleotide DNA.

The response to a DNA vaccine has been shown to be increased by the presence of immunostimulatory DNA sequences (ISS). These can take the form of hexameric motifs containing methylated CpG, according to the formula : 5'-purine-purine-CG-pyrimidine-pyrimidine-3'. Our DNA vaccines may therefore incorporate these or other ISS, in the DNA encoding the telomerase peptide or protein, in the DNA encoding the cytokine or other co-stimulatory molecules, or in both. A review of the advantages of DNA vaccination is provided by Tighe et al (1998, *Immunology Today,* 19(2), 89-97).

We describe a method of treatment of a patient afflicted with cancer, the method comprising eliciting T-cell responses through stimulating *in vivo* or *ex vivo* with a telomerase protein or peptide. The telomerase protein or peptide can also be used in a method of vaccination of a patient in order to obtain resistance against cancer. A suitable method of vaccination comprises eliciting T-cell responses through

stimulating *in vivo* or *ex vivo* with a telomerase protein or peptide. We also describe a method of treatment or prophylaxis of cancer, comprising administering to a mammal suffering or likely to suffer from cancer a therapeutically effective amount of a telomerase protein or peptide so that a T cell response against telomerase is induced in the mammal.

The peptides described here may be produced by conventional processes, for example, by the various peptide synthesis methods known in the art. Alternatively, they may be fragments of a telomerase protein produced by cleavage, for example, using cyanogen bromide, and subsequent purification. Enzymatic cleavage may also be used. The telomerase proteins or peptides may also be in the form of recombinant expressed proteins or peptides.

Nucleic acids encoding the telomerase peptide can be made by oligonucleotide synthesis. This may be done by any of the various methods available in the art. A nucleic acid encoding telomerase protein may be cloned from a genomic or cDNA library, using conventional library screening. The probe may correspond to a portion of any sequence of a known telomerase gene. Alternatively, the nucleic acid can be obtained by using the Polymerase Chain Reaction (PCR). The nucleic acid is preferably DNA, and may suitably be cloned into a vector. Subclones may be generated by using suitable restriction enzymes. The cloned or subcloned DNA may be propagated in a suitable host, for example a bacterial host. Alternatively, the host can be a eukaryotic organism, such as yeast or baculovirus. The telomerase protein or peptides may be produced by expression in a suitable host. In this case, the DNA is cloned into an expression vector. A variety of commercial expression kits are available. The methods described in Maniatis et al (1991, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor, New York, Cold Spring Harbor Laboratory Press) and Harlow and Lane (1988,

Antibodies: A Laboratory Manual, Cold Spring Harbor, New York, Cold Spring Harbor Laboratory Press) may be used for these purposes.

Experimental Methods

The peptides were synthesised by using continuous flow solid phase peptide synthesis. N-a-Fmoc-amino acids with appropriate side chain protection were used. The Fmoc-amino acids were activated for coupling as pentafluorophenyl esters or by using either TBTU or diisopropyl carbodiimide activation prior to coupling. 20% piperidine in DMF was used for selective removal of Fmoc after each coupling. Cleavage from the resin and final removal of side chain protection was performed by 95% TFA containing appropriate scavengers. The peptides were purified and analysed by reversed phase (C18) HPLC. The identify of the peptides was confirmed by using electro-spray mass spectroscopy (Finnigan mat SSQ710).

In order for a cancer vaccine and methods for specific cancer therapy based on T cell immunity to be effective, three conditions must be met:

(a) the peptide is at least 8 amino acids long and is a fragment of a telomerase protein and

(b) the peptide is capable of inducing, either in its full length or after processing by antigen presenting cell, T cell responses.

The following experimental methods may be used to determine if these three conditions are met for a particular peptide. First, it should be determined if the particular peptide gives rise to T cell immune responses *in vitro*. It will also need to be established if the synthetic peptides correspond to, or are capable after processing to yield, peptide fragments corresponding to peptide fragments occurring in

cancer cells harbouring telomerase or antigen presenting cells that have processed naturally occurring telomerase. The specificity of T cells induced *in vivo* by telomerase peptide vaccination may also be determined.

It is necessary to determine if telomerase expressing tumour cell lines can be killed by T cell clones obtained from peripheral blood from carcinoma patients after telomerase peptide vaccination. T cell clones are obtained after cloning of T-cell blasts present in peripheral blood mononuclear cells (PBMC) from a carcinoma patient after telomerase peptide vaccination. The peptide vaccination protocol includes several *in vivo* injections of peptides intracutaneously with GM-CSF or another commonly used adjuvant. Cloning of T cells is performed by plating responding T cell blasts at 5 blasts per well onto Terasaki plates. Each well contains 2×10^4 autologous, irradiated (30 Gy) PBMC as feeder cells. The cells are propagated with the candidate telomerase peptide at 25 mM and 5 U/ml recombinant interleukin-2 (rIL-2) (Amersham, Aylesbury, UK) in a total volume of 20 mL. After 9 days T cell clones are transferred onto flat-bottomed 96-well plates (Costar, Cambridge, MA) with 1 mg/ml phytohemagglutinin (PHA, Wellcome, Dartford, UK), 5 U/ml rIL-2 and allogenic irradiated (30 Gy) PBMC (2×10^5) per well as feeder cells. Growing clones are further expanded in 24-well plates with PHA / rIL-2 and 1×10^6 allogenic, irradiated PBMC as feeder cells and screened for peptide specificity after 4 to 7 days.

T cell clones are selected for further characterisation. The cell-surface phenotype of the T cell clone is determined to ascertain if the T cell clone is CD4+ or CD8+. T cell clone is incubated with autologous tumour cell targets at different effector to target ratios to determine if lysis of tumour cells occurs. Lysis indicates that the T cell has reactivity

directed against a tumour derived antigen, for example, telomerase protein.

In order to verify that the antigen recognised is associated with telomerase protein, and to identify the HLA class I or class II molecule presenting the putative telomerase peptide to the T cell clone, different telomerase expressing tumour cell lines carrying one or more HLA class I or II molecules in common with those of the patient are used as target cells in cytotoxicity assays. Target cells are labelled with ^{51}Cr or ^{3}H-thymidine (9.25×10^4 Bq/mL) overnight, washed once and plated at 5000 cells per well in 96 well plates. T cells are added at different effector to target ratios and the plates are incubated for 4 hours at 37°C and then harvested before counting in a liquid scintillation counter (Packard Topcount). For example, the bladder carcinoma cell line T24 ($12Val^+$, $HLA-A1^+$, $B35^+$), the melanoma cell line FMEX ($12Val^+$, $HLA-A2^+$, $B35^+$) and the colon carcinoma cell line SW 480 ($12Val^+$, $HLA-A2^+$, $B8^+$) or any other telomerase positive tumour cell line may be used as target cells. A suitable cell line which does not express telomerase protein may be used as a control, and should not be lysed. Lysis of a particular cell line indicates that the T cell clone being tested recognises an endogenously-processed telomerase epitope in the context of the HLA class I or class II subtype expressed by that cell line.

The HLA class I or class II restriction of a T cell clone may be determined by blocking experiments. Monoclonal antibodies against HLA class I antigens, for example the panreactive HLA class I monoclonal antibody W6/32, or against class II antigens, for example, monoclonals directed against HLA class II DR, DQ and DP antigens (B8/11, SPV-L3 and B7/21), may be used. The T cell clone activity against the autologous tumour cell line is evaluated using monoclonal antibodies directed against HLA class I and class II molecules at a final concentration of 10 mg/ml. Assays are set up as described

above in triplicate in 96 well plates and the target cells are preincubated for 30 minutes at 37°C before addition of T cells.

The fine specificity of a T cell clone may be determined using peptide pulsing experiments. To identify the telomerase peptide actually being recognised by a T cell clone, a panel of nonamer peptides is tested. ^{51}Cr or ^{3}H-thymidine labelled, mild acid eluted autologous fibroblasts are plated at 2500 cells per well in 96 well plates and pulsed with the peptides at a concentration of 1 mM together with b2-microglobulin (2.5 mg/mL) in a 5% CO_2 incubator at 37°C before addition of the T cells. Assays are set up in triplicate in 96 well plates and incubated for 4 hours with an effector to target ratio of 5 to 1. Controls can include T cell clone cultured alone, with APC in the absence of peptides or with an irrelevant melanoma associated peptide MART-1/Melan-A peptide.

An alternative protocol to determine the fine specificity of a T cell clone may also be used. In this alternative protocol, the TAP deficient T2 cell line is used as antigen presenting cells. This cell line expresses only small amounts of HLA-A2 antigen, but increased levels of HLA class I antigens at the cell surface can be induced by addition of b2-microglobulin. ^{3}H-labelled target cells are incubated with the different test peptides and control peptides at a concentration of 1 mM together with b2-microglobulin (2.5 mg/mL) for one hour at 37°C. After peptide pulsing, the target cells are washed extensively, counted and plated at 2500 cells per well in 96 well plates before addition of the T cells. The plates are incubated for 4 hours at 37°C in 5% CO_2 before harvesting. Controls include T cell clone cultured alone or with target cells in the absence of peptides. Assays were set up in triplicate in 96 well plates with an effector to target ratio of 20 to 1.

The sensitivity of a T cell clone to a particular peptide identified above may also be determined using a dose-response experiment. Peptide sensitised fibroblasts can be used as target cells. The target cells are pulsed with the particular peptide as described above for fine specificity determination, with the exception that the peptides are added at different concentrations before the addition of T cells. Controls include target cells alone and target cells pulsed with the irrelevant melanoma associated peptide Melan-A/Mart-1.

Table 1

LMSVYVVEL	FLHWLMSVYVVELLRSFFYVTE
ELLRSFFYV	EARPALLTSRLRFIPK
YVVELLRSF	DGLRPIVNMDYVVGAR
VVELLRSFF	GVPEYGCVVNLRKVVNF
SVYVVELLR	
VELLRSFFY	
YVTETTFQK	
RLFFYRKSV	
SIGIRQHLK	
RPALLTSRL	
ALLTSRLRF	
LLTSRLRFI	
RPIVNMDYV	
LRPIVNMDY	
YVVGARTFR	
VVGARTFRR	
GARTFRREK	
ARTFRREKP	
PPELYFVKV	
ELYFVKVDV	
FVKVDVTGA	
IPQDRLTEV	
DRLTEVIAS	
RLTEVIASI	
IPQGSILSTL	
ILSTLLCSL	
LLRLVDDFL	
RLVDDFLLV	
VPEYGCVVN	
VPEYGCVVNL	
TLVRGVPEY	
FLRTLVRGV	
GVPEYGCVV	
VVNLRKTVV	
GLFPWCGLL	

Table 2

YAETKHFLY
ISDTASLCY
DTDPRRLVQ
AQDPPPELY
LTDLQPYMR
QSDYSSYAR
ILAKFLHWL
ELLRSFFYV
LLARCALFV
WLCHQAFLL
RLVDDFLLV
RLFFYRKSV
LQLPFHQQV
RLGPQGWRL
SLQELTWKM
NVLAFGFAL
VLLKTHCPL
FLLVTPHLT
TLTDLQPYM
RLTEVIASI
FLDLQVNSL
SLNEASSGL
ILSTLLCSL
LLGASVLGL
VLAFGFALL
LQPYMRQFV
LMSVYVVEL
RLPQRYWQM
RQHSSPWQV
YLPNTVTDA
NMRRKLFGV
RLTSRVKAL
LLQAYRFHA
LLDTRTLEV
YMRQFVAHL
LLTSRLRFI
CLVCVPWDA
LLSSLRPSL

<u>Table 2 (Continued)</u>

FMCHHAVRI
LQVNSLQTV
LVAQCLVCV
CLKELVARV
FLRNTKKFI
ALPSDFKTI
VLVHLLARC
VQSDYSSYA
SVWSKLQSI
KLPGTTLTA
QLSRKLPGT
ELYFVKVDV
GLLLDTRTL
WMPGTPRRL
SLTGARRLV
VVIEQSSSL
LPSEAVQWL
QAYRFHACV

GLFDVFLRF
KLFGVLRLK
RLREEILAK
TLVRGVPEY
GLPAPGARR
GLFPWCGLL
KLTRHRVTY
VLPLATFVR
ELVARVLQR

DPRRLVQLL
FVRACLRRL
SVREAGVPL
AGRNMRRKL
LARCALFVL
RPAEEATSL
LPSDFKTIL
LPSEAVQWL
LPGTTLTAL
RPSFLLSSL
LPNTVTDAL
RPALLTSRL

Table 2 (Continued)

RCRAVRSLL
MPRAPRCRA
GIRRDGLLL
VLRLKCHSL
YMRQFVAHL
SLRTAQTQL
QMRPLFLEL
LLRLVDDFL
FVQMPAHGL
HASGPRRRL
VVIEQSSSL
RVISDTASL
CVPAAEHRL
RVKALFSVL
NVLAFGFAL
LVARVLQRL
FAGIRRDGL
HAQCPYGVL
RAQDPPPEL
AYRFHACVL
HAKLSLQEL
GAKGAAGPL
TASLCYSIL
APRCRAVRS
GARRLVETI
AQCPYGVLL
HAKTFLRTL
EATSLEGAL
KAKNAGMSL
AQTQLSRKL
AGIRRDGLL
VLRLKCHSL
ILKAKNAGM
DPRRLVQLL
GAKGAAGPL
FAGIRRDGL
GARRRGGSA
HAKTFLRTL
HAKLSLQEL

Table 2 (Continued)

LARCALFVL
EHRLREEIL
NMRRKLFGV

CAREKPQGS
LTRHRVTYV

RRFLRNTKK
RRDGLLLRL
RREKRAERL
RRLVETIFL
LRFMCHHAV
RRYAVVQKA
KRAERLTSR
RRKLFGVLR
RRRGGSASR
RRLPRLPQR
RRLGPQGWR
LRGSGAWGL
HREARPALL
VRRYAVVQK
ARTSIRASL
HRVTYVPLL
LRSHYREVL
MRPLFLELL
HRAWRTFVL
MRRKLFGVL
LRLVDDFLL
LRRVGDDVL
YRKSVWSKL
QRLCERGAK
FRALVAQCL
SRKLPGTTL
LRRLVPPGL
RRSPGVGCV
RRVGDDVLV
VRGCAWLRR
VRSLLRSHY
ARTFRREKR
SRSLPLPKR
IRASLTFNR

Table 2 (Continued)

LREEILAKF
IRRDGLLLR
QRGDPAAFR
LRPIVNMDY
ARRLVETIF
ARPALLTSR
LRPSLTGAR
LRLKCHSLF
FRREKRAER
ARGGPPEAF
CRAVRSLLR
GRTRGPSDR
RRRLGCERA
LRELSEAEV
ARCALFVLV
RPAEEATSL
DPRRLVQLL
RPSFLLSSL
LPSEAVQWL
RPALLTSRL
LPSDFKTIL
RPPPAAPSF
LPRLPQRYW
LPNTVTDAL
LPGTTLTAL
LAKFLHWLM
KAKNAGMSL
GSRHNERRF
KALFSVLNY
SPLRDAVVI
RAQDPPPEL
MPAHGLFPW
AEVRQHREA
REAGVPLGL
EEATSLEGA
LEAAANPAL
QETSPLRDA
REVLPLATF

Table 2 (Continued)

KEQLRPSFL
REKPQGSVA
LEVQSDYSS
REARPALLT
EEDTDPRRL
REEILAKFL
CERGAKNVL
DDVLVHLLA
GDMENKLFA
YERARRPGL

CLAIMS

1. A telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer.

2. A telomerase protein or peptide as claimed in Claim 1 for a use as specified therein, the telomerase protein or peptide being capable of generating a T cell response directed against the telomerase protein.

3. A telomerase protein or peptide as claimed in Claim 1 or 2 for a use as specified therein, in which the method comprises administering to a mammal suffering or likely to suffer from cancer a therapeutically effective amount of the telomerase protein or peptide so that a T cell response against the telomerase is induced in the mammal.

4. A telomerase protein or peptide as claimed in Claim 2 or 3 for a use as specified therein, in which the T cell response induced is a cytotoxic T cell response.

5. A telomerase protein or peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase protein or peptide is a human telomerase protein or peptide.

6. A telomerase peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase peptide has a length of between 8 and 25 amino acids.

7. A telomerase peptide as claimed in Claim 6 for a use as specified therein, in which the peptide has a length of 9, 12, 13, 16 or 21 amino acids.

8. A telomerase peptide as claimed in any of Claims 1 to 5 for a use as specified therein, in which the peptide has a length of at least 9 amino acids.

9. A telomerase peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase peptide has an amino acid sequence which partially or totally overlaps a sequence selected from any of the following sequences: LLRSFFYVTE, SRLRFIPK, LRPIVNMDYVVG, PELYFVKVDVTGAYDTI, KSYVQCQGIPQGSILSTLLCSLCY, LLLRLVDDFLLVT, GCVVNLRKTVV, WLMSVYVVELLRSFFYVTETTFQKNRLFFYRKSVWSKLQSIGIRQHLK, EVRQHREARPALLTSRLRFIPKPDG, LRPIVNMDYVVGARTFRREKRAERLTSRV, PPPELYFVKVDVTGAYDTIPQDRLTEVIASIIKP, KSYVQCQGIPQGSILSTLLCSLCYGDMENKLFAGI, LLRLVDDFLLVTPHLTH, AKTFLRTLVRGVPEYGCVVNLRKTVV and HGLFPWCGLLL.

10. A telomerase peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase peptide has an amino acid sequence: LMSVYVVEL, ELLRSFFYV, YVVELLRSF, VVELLRSFF, SVYVVELLR, VELLRSFFY, YVTETTFQK, RLFFYRKSV, SIGIRQHLK, RPALLTSRL, ALLTSRLRF, LLTSRLRFI, RPIVNMDYV, LRPIVNMDY, YVVGARTFR, VVGARTFRR, GARTFRREK, ARTFRREKP, PPELYFVKV, ELYFVKVDV, FVKVDVTGA, IPQDRLTEV, DRLTEVIAS, RLTEVIASI, IPQGSILSTL, ILSTLLCSL, LLRLVDDFL, RLVDDFLLV, VPEYGCVVN, VPEYGCVVNL, TLVRGVPEY, FLRTLVRGV, GVPEYGCVV, VVNLRKTVV or GLFPWCGLL.

11. A telomerase peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase peptide has an amino acid sequence: FLHWLMSVYVVELLRSFFYVTE, EARPALLTSRLRFIPK, DGLRPIVNMDYVVGAR or GVPEYGCVVNLRKVVNF, i.e. seq. id no. 1, 2, 3 or 4 respectively.

12. A telomerase peptide as claimed in any of the preceding claims for a use as specified therein, in which the telomerase peptide has an amino acid sequence: YAETKHFLY, ISDTASLCY, DTDPRRLVQ, AQDPPPELY, LTDLQPYMR, QSDYSSYAR, ILAKFLHWL, ELLRSFFYV, LLARCALFV, WLCHQAFLL, RLVDDFLLV, RLFFYRKSV, LQLPFHQQV, RLGPQGWRL, SLQELTWKM, NVLAFGFAL, VLLKTHCPL, FLLVTPHLT, TLTDLQPYM, RLTEVIASI, FLDLQVNSL, SLNEASSGL, ILSTLLCSL, LLGASVLGL, VLAFGFALL, LQPYMRQFV, LMSVYVVEL, RLPQRYWQM, RQHSSPWQV, YLPNTVTDA, NMRRKLFGV, RLTSRVKAL, LLQAYRFHA, LLDTRTLEV, YMRQFVAHL, LLTSRLRFI, CLVCVPWDA, LLSSLRPSL, FMCHHAVRI, LQVNSLQTV, LVAQCLVCV, CLKELVARV, FLRNTKKFI, ALPSDFKTI, VLVHLLARC, VQSDYSSYA, SVWSKLQSI, KLPGTTLTA, QLSRKLPGT, ELYFVKVDV, GLLLDTRTL, WMPGTPRRL, SLTGARRLV, VVIEQSSSL, LPSEAVQWL, QAYRFHACV, GLFDVFLRF, KLFGVLRLK, RLREEILAK, TLVRGVPEY, GLPAPGARR, GLFPWCGLL, KLTRHRVTY, VLPLATFVR, ELVARVLQR, DPRRLVQLL, FVRACLRRL, SVREAGVPL, AGRNMRRKL, LARCALFVL, RPAEEATSL, LPSDFKTIL, LPSEAVQWL, LPGTTLTAL, RPSFLLSSL, LPNTVTDAL, RPALLTSRL, RCRAVRSLL, MPRAPRCRA, GIRRDGLLL, VLRLKCHSL, YMRQFVAHL, SLRTAQTQL, QMRPLFLEL, LLRLVDDFL, FVQMPAHGL, HASGPRRRL, VVIEQSSSL, RVISDTASL, CVPAAEHRL, RVKALFSVL, NVLAFGFAL, LVARVLQRL, FAGIRRDGL, HAQCPYGVL, RAQDPPPEL, AYRFHACVL, HAKLSLQEL, GAKGAAGPL, TASLCYSIL, APRCRAVRS, GARRLVETI, AQCPYGVLL, HAKTFLRTL, EATSLEGAL, KAKNAGMSL, AQTQLSRKL, AGIRRDGLL, VLRLKCHSL, ILKAKNAGM, DPRRLVQLL, GAKGAAGPL, FAGIRRDGL, GARRRGGSA, HAKTFLRTL, HAKLSLQEL, LARCALFVL, EHRLREEIL, NMRRKLFGV, CAREKPQGS, LTRHRVTYV, RRFLRNTKK, RRDGLLLRL, RREKRAERL, RRLVETIFL, LRFMCHHAV, RRYAVVQKA, KRAERLTSR, RRKLFGVLR, RRRGGSASR, RRLPRLPQR, RRLGPQGWR, LRGSGAWGL, HREARPALL, VRRYAVVQK, ARTSIRASL, HRVTYVPLL, LRSHYREVL, MRPLFLELL, HRAWRTFVL, MRRKLFGVL, LRLVDDFLL, LRRVGDDVL, YRKSVWSKL, QRLCERGAK, FRALVAQCL, SRKLPGTTL, LRRLVPPGL, RRSPGVGCV, RRVGDDVLV, VRGCAWLRR, VRSLLRSHY, ARTFRREKR, SRSLPLPKR, IRASLTFNR, LREEILAKF, IRRDGLLLR, QRGDPAAFR, LRPIVNMDY, ARRLVETIF, ARPALLTSR, LRPSLTGAR, LRLKCHSLF, FRREKRAER, ARGGPPEAF, CRAVRSLLR, GRTRGPSDR, RRRLGCERA, LRELSEAEV, ARCALFVLV, RPAEEATSL,

DPRRLVQLL, RPSFLLSSL, LPSEAVQWL, RPALLTSRL, LPSDFKTIL, RPPPAAPSF, LPRLPQRYW, LPNTVTDAL, LPGTTLTAL, LAKFLHWLM, KAKNAGMSL, GSRHNERRF, KALFSVLNY, SPLRDAVVI, RAQDPPPEL, MPAHGLFPW, AEVRQHREA, REAGVPLGL, EEATSLEGA, LEAAANPAL, QETSPLRDA, REVLPLATF, KEQLRPSFL, REKPQGSVA, LEVQSDYSS, REARPALLT, EEDTDPRRL, REEILAKFL, CERGAKNVL, DDVLVHLLA, GDMENKLFA or YERARRPGL.

13. A nucleic acid for use in a method of treatment or prophylaxis of cancer, the nucleic acid being capable of encoding a telomerase protein or peptide as claimed in any of the preceding claims.

14. A pharmaceutical composition comprising at least one telomerase protein or peptide as claimed in any of Claims 1 to 12, or at least one nucleic acid as claimed in Claim 13, together with a pharmaceutically acceptable carrier or diluent.

15. A pharmaceutical composition comprising a combination of at least one telomerase protein or peptide as claimed in any of Claims 1 to 12 and at least one peptide capable of inducing a T cell response against an oncogene or mutant tumour suppressor protein or peptide, together with a pharmaceutically acceptable carrier or diluent.

16. A pharmaceutical composition as claimed in Claim 14 or 15 for use in the treatment or prophylaxis of any of the following cancers: breast cancer, prostate cancer, pancreatic cancer, colo-rectal cancer, lung cancer, malignant melanoma, leukaemias, lymphomas, ovarian cancer, cervical cancer and biliary tract carcinomas.

17. A method for the preparation of a pharmaceutical composition as claimed in Claim 14, in which the method comprises mixing at least one telomerase protein or peptide as claimed in any of Claims 1 to 12, or at least one nucleic acid as claimed in Claim 13, with a pharmaceutically acceptable carrier or diluent.

18. A method for the preparation of a pharmaceutical composition as claimed in Claim 15, in which the method comprises mixing at least one telomerase protein or peptide as claimed in any of Claims 1 to 12, with at least one peptide capable of inducing a T cell response against an oncogene or mutant tumour suppressor protein or peptide, and a pharmaceutically acceptable carrier or diluent.

19. A pharmaceutical composition as claimed in Claim 15 or a method of making a pharmaceutical composition as claimed in Claim 18, in which the oncogene protein or peptide is a mutant p21-*ras* protein or peptide.

20. A pharmaceutical composition as claimed in claimed in Claim 15 or a method of making a pharmaceutical composition as claimed in Claim 18, in which the tumour suppressor protein or peptide is a retinoblastoma or p53 protein or peptide.

21. The use, in the preparation of a medicament for the treatment or prophylaxis of cancer, of a telomerase protein or peptide, or a nucleic acid capable of encoding a telomerase protein or peptide.

22. A method of generating T lymphocytes capable of recognising and destroying tumour cells in a mammal, in which the method comprises taking a sample of T lymphocytes from a mammal, and culturing the T lymphocyte sample in the presence of telomerase protein or peptide in an amount sufficient to generate telomerase T lymphocytes.

23. A telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer substantially as hereinbefore described with reference to and as shown in the drawing.

24. The use, in the preparation of a medicament for the treatment or prophylaxis of cancer, of a telomerase protein or peptide, or a nucleic acid capable of encoding a telomerase protein or peptide, substantially as hereinbefore described with reference to and as shown in the drawing.

25. A nucleic acid capable of encoding a telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer substantially as hereinbefore described with reference to and as shown in the drawing.

26. A pharmaceutical composition or a method of preparation of such a pharmaceutical composition comprising at least one telomerase protein or peptide substantially as hereinbefore described with reference to and as shown in the drawing.

27. A method of generating telomerase T lymphocytes substantially as hereinbefore described.

Sequence Identity List

SEQUENCE LISTING

COMMON FOR ALL SEQUENCES.

SEQUENCE TYPE: Peptide

SEQUENCE UNIT: Amino Acid

TOPOLOGY: Linear

SEQUENCE ID NO: 1

SEQUENCE LENGTH: 22 amino acids

```
F L H W L M S V Y V V E L L R S F F Y V T E
1       5         10        15        20
```

SEQUENCE ID NO: 2

SEQUENCE LENGTH: 16 amino acids

```
E A R P A L L T S R L R F I P K
1       5         10        15
```

SEQUENCE ID NO: 3

SEQUENCE LENGTH: 16 amino acids

```
D G L R P I V N M D Y V V G A R
1       5         10        15
```

SEQUENCE ID NO: 4

SEQUENCE LENGTH: 18 amino acids

```
G V P E Y G C V V N L R K T V V N F
1       5         10        15
```

Abstract

This invention relates to proteins or peptides which elicit T cell mediated immunity, and to cancer vaccines and compositions for anti-cancer treatment comprising such proteins or peptide fragments. This invention also relates to pharmaceutical compositions comprising the proteins or peptides and methods for generating T lymphocytes capable of recognising and destroying tumour cells in a mammal.

More specificly, a telomerase protein or peptide for use in a method of treatment or prophylaxis of cancer is provided. In a preferred embodiment, the method comprises generating a T cell response against telomerase.

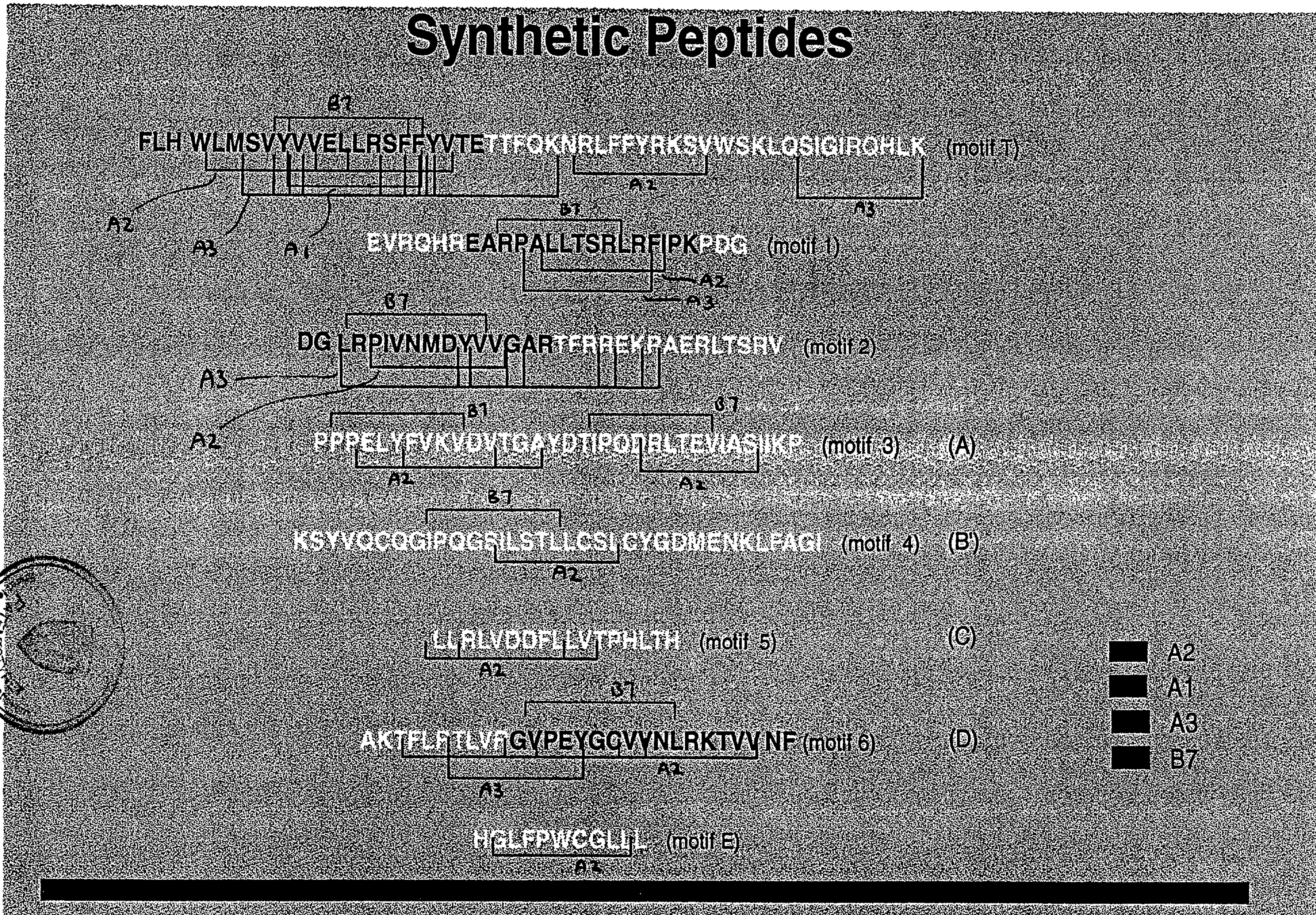
Synthetic Peptides
FLH WLMSVYVVELLRSFFYVTETTFQKNRLFFYRKSVWSKLQSIGIRQHLK (motif T)
EVRQHREARPALLTSRLRFIPKPDG (motif 1)
DG LRPIVNMDYVVGARTFRREKRAERLTSRV (motif 2)
PPPELYFVKVDVTGAYDTIPQDRLTEVIASIIKP (motif 3) (A)
KSYVQCQGIPQGSILSTLLCSLCYGDMENKLFAGI (motif 4) (B')
LLRLVDDFLLVTPHLTH (motif 5) (C)
AKTFLRTLVRGVPEYGCVVNLRKTVVNF (motif 6) (D)
HGLFPWCGLLL (motif E)
B7
A2
A3
A1
A2
A3
A2
A3
A2
A2
A2
A1
A3
B7

FIGURE 1